

THE PSEUDODIAPATOMIDAE (COPEPODA; CALANOIDA)
OF SOUTHERN AFRICAN WATERS, INCLUDING A NEW SPECIES,
Pseudodiaptomus charteri

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(With 5 figures in the text)

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INTRODUCTION

The Pseudodiaptomidae are a very interesting group of calanoid copepods which occur in marine, brackish and fresh water in many parts of the world. They are frequently the dominant organisms within their particular habitat, while their interesting distribution makes them of zoogeographical importance. While working on the plankton of South African estuaries it became clear to me that a revision of the South African species of Pseudodiaptomidae was required. The only Pseudodiaptomid previously recorded from southern African waters was *Pseudodiaptomus serricaudatus* (Cleve, 1904; Marques, 1958; etc.). I was, however, doubtful whether our specimens should be referred to this species for they differed slightly from the form originally described by T. Scott (1894). Tanaka (1960) confirmed my opinion by describing specimens of the South African form, obtained from the Agulhas bank by the Japanese Antarctic Research Expedition, as a new species, *Pseudodiaptomus nudus*. This species occurs chiefly in neritic waters. Two species of *Pseudodiaptomus* are the dominant planktonic animals in South African estuaries and lagoons. One species from the west and south coasts was found to be *Pseudodiaptomus hessei* which was recorded (in a preliminary report only) from the mouth of the Congo (Mrázek, 1894). After this it does not appear to have been reported again, and it was never fully described. The species found on the Natal coast was apparently previously unknown and is described here. A complete description

is given of *P. hessei* and the other species are described largely by comparison with it. The terminology I have used to describe the regions of the copepod body follows the recommendations of Gooding (1957).

Family **Pseudodiaptomidae**

Genus **PSEUDODIAPTONUS**

Pseudodiaptomus Herrick 1884, 180.

Schmackeria (non Poppe & Richard 1890) Mrázek 1894, 1.

Heterocalanus T. Scott 1894, 39.

Weismanella Dahl 1894, 10.

Head smoothly rounded, separated from or fused with first pedigerous prosome segment. Fourth and fifth pedigerous segments usually fused, with rounded or pointed posterior angles, frequently bearing spines or hairs, particularly in the female. Genital segment of the female usually swollen, bearing setae and spines arranged asymmetrically. Caudal rami at least twice as long as wide, caudal setae often jointed or thickened. First four pairs of legs biramous, rami 3-segmented. Female fifth legs uniramous and 4-segmented. Male fifth legs 4-segmented, uniramous or bearing 1-segmented endopods on either or both legs. The right endopod, when present, is usually rudimentary. Three species represented in southern African waters. *Pseudodiaptomus pelagicus* Herrick (1884), which is the type of the genus, has not been seen since that time and the original description is brief and the figures unfortunately poor.

Pseudodiaptomus hessei (Mrázek)

(Figs. 1 a-k; 2 a-f; 3 a-f)

Schmackeria hessei Mrázek 1894, 1, figs. 1, 2, 3.

Pseudodiaptomus hessei (Mrázek) Giesbrecht & Schmeil 1898, 65. Marsh 1933, 36, pl. 19, figs. 1, 2.

Occurrence

Abundant in estuaries and lagoons on the west and south coasts of South Africa as far east as the Kleinmond estuary (Bathurst division). Material from the latter locality was collected for me by Professor J. Omer-Cooper. Specimens have been found in water with salinity ranging from about 10‰ to over 40‰.

Known distribution

Banana Creek (brackish water) at the mouth of the Congo River (Mrázek, 1894).

Description

FEMALE: Length 1.55–1.80 mm. (1.20 mm., Mrázek). Prosome slender viewed dorsally approximately two and a half times as long as wide, rounded anteriorly (fig. 1 a, b). Fourth and fifth pedigerous segments fused. Posterior angles of metasome bearing a sharp spine on each side on the postero-dorsal margin. Rostrum well developed with two strong filaments which reach the middle of the proximal segment of the first antennae.

Urosome 4-segmented and about two-thirds as long as prosome. Genital segment (fig. 1 *f*, *h*) asymmetrical, with irregular swellings laterally and a prominent genital boss ventrally. A number of setae are present mainly on the lateral swellings, and there is a patch of fine hairs in the middle of the dorsal surface. The genital boss is of characteristic form. It bears a row of spinules anteriorly and the genital flaps each have a distal seta. The first three urosome segments are furnished with rows of coarse teeth on their postero-dorsal margins. The caudal rami (fig. 1 *g*) are divergent, more than three times as long as wide and furnished with fine hairs on their inner margins. The third or middle caudal seta (not counting the sensory bristle between the fourth and fifth setae) is broad and flattened in a characteristic blade-like form. It is about three times as wide as the other setae and is easily visible under low magnification so that it is a useful feature for distinguishing the females of this species. Similar broad setae occur in a number of species of the *Schmackeria* group from Asia.

Antenna 1 (fig. 1 *c*) of 21 segments, reaching the second urosome segment when extended. Segments 1 + 2, 3 + 4, 8 + 9 and 24 + 25 apparently fused. Proportional lengths and setation of segments as shown in figure 1 *c*. Giesbrecht and Schmeil (1898) and Marsh (1933) reported 22 segments, but Mrázek (1894) does not mention the number of segments.

There is one aesthetaske on each segment up to and including no. 16, one on no. 19 and one on the terminal segment. (Aesthetasks are not shown in figure 1 *c*.) A specialized comb-like seta (fig. 1 *i*) is present on the third last segment. It lies parallel to the antenna so that it is not readily noticed. Its distal end is curved and slightly expanded and bears about three distinct recurved hooks and a number of much smaller ones which grade into a series of minute comb-like teeth (3μ long and 1μ apart) along the shaft of the seta. There is a bulbous swelling near the base of this seta. There is also an unspecialized plumose seta on this segment. The comb-like seta is an interesting feature, for modified setae (apparently of varying form) have been described on this segment of the first antenna of the female and the unmodified antenna of the male from a number of widely scattered species within the genus. Some form of comb-like seta has been noted in *Pseudodiaptomus stuhlmanni*, *P. serricaudatus* and *P. hessei* (Poppe and Mrázek, 1895); *P. richardi* (Mrázek, 1901); *P. hickmani*, *P. masoni* and *P. salinus* (Seymour Sewell, 1932); *P. ardjuna* (Ummerkutty, 1961), and *P. charteri* and *P. nudus* in this present work. This feature thus occurs in species from America to the orient and is not confined to any particular subgroup of this genus.

Antenna 2 (fig. 2 *a*) with basipod partially divided by an incomplete suture, bearing 1 lateral and 2 terminal setae. Exopod 3-segmented, third segment only partially separated, bearing 2 setae on the first segment, 7 setae on the second, and 6 terminal setae and a lateral fringe of fine hairs on the distal segment. Endopod apparently 4-segmented, third segment small and indistinct, bearing 1 seta on segment 1, 2 lateral and 3 distal on segment 2, 1 on segment 3 and 2 lateral and 3 terminal on segment 4.

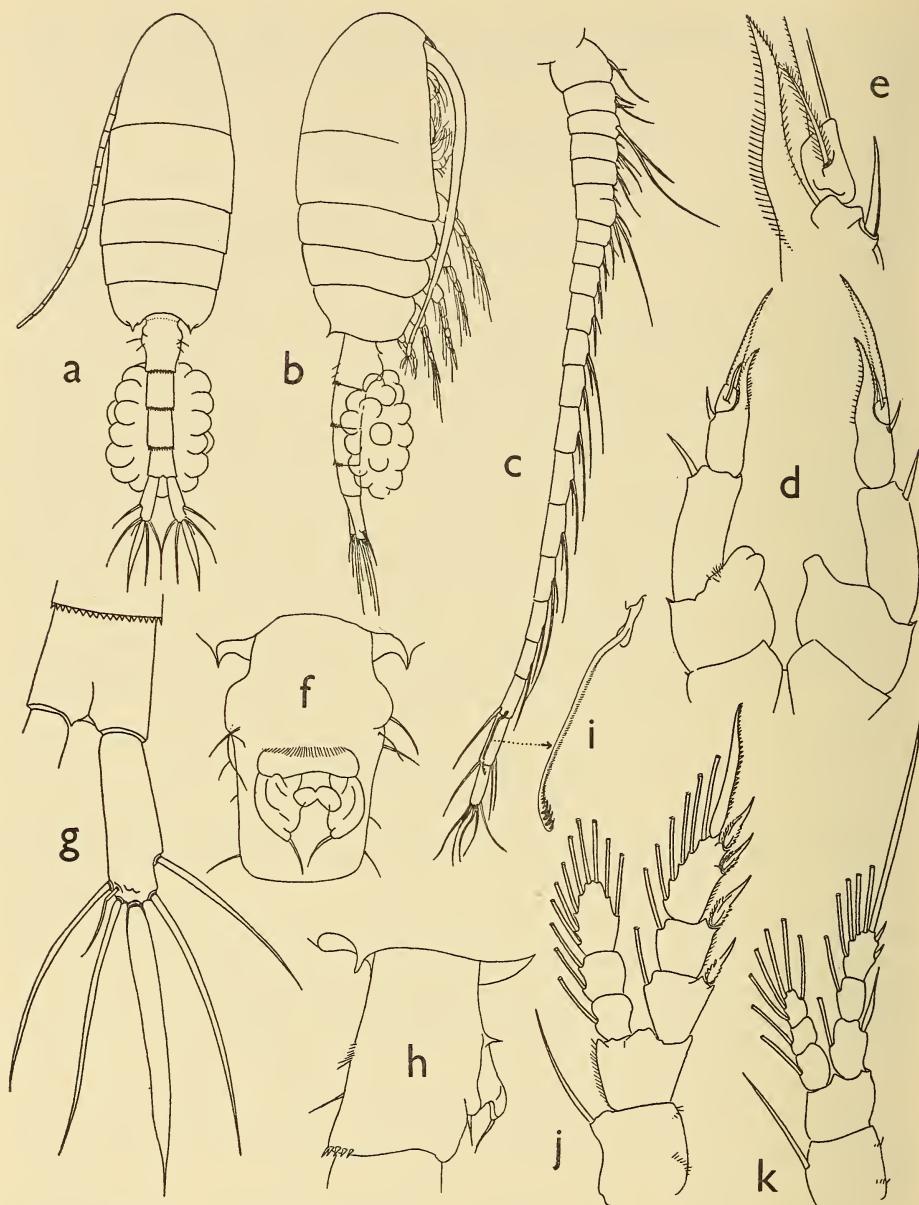


FIG. 1. *Pseudodiaptomus hessei* (Mrázek). *a*, ♀ dorsal; *b*, ♀ lateral; *c*, antenna 1 ♀; *d*, fifth legs ♀; *e*, distal part of latter enlarged; *f*, ♀ genital segment ventral; *g*, caudal ramus ♀; *h*, ♀ genital segment lateral; *i*, comb-like seta enlarged; *j*, fourth swimming leg; *k*, first swimming leg.

Mandible (fig. 2 c) with gnathal lobe heavily chitinized and bearing about 10 fine teeth and a plumose spinule. Basipod of palp with 4 inner marginal setae. Exopod indistinctly 3-segmented, bearing 1 lateral and 5 terminal setae. Endopod 2-segmented, bearing 4 setae on segment 1 (1 separate) and 8 setae distally on segment 2 (1 jointed and crooked). This last segment is narrowly triangular and bears a row of tiny bristles.

Maxilla 1 (fig. 2 d) with first inner lobe or gnathobase bearing about 10 strong spines, small second inner lobe bearing ?3 setae and third inner lobe bearing 3 terminal setae. Outer lobe or coxal epipod bearing 8 long setae. Exopod with 9 marginal setae. Endopod 3-segmented bearing 4 setae medially

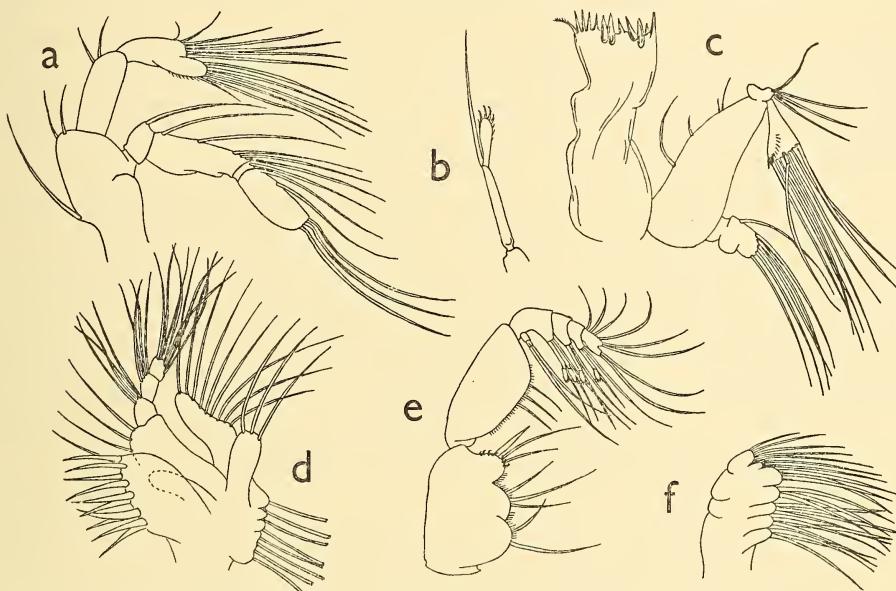


FIG. 2. *Pseudodiaptomus hessei* (Mrázek). a, antenna 2; b, divided seta from maxilliped; c, mandible; d, maxilla 1; e, maxilliped; f, maxilla 2.

on the basal portion (second basal segment) and groups of 4 setae medially on segments 1 and 2 and approximately 7 terminal setae on segment 3.

Maxilla 2 (fig. 2 f) with 5 large medial lobes or endites and 2 smaller terminal lobes each bearing 3 or 4 setae. Distal portion indistinctly segmented.

Maxilliped (fig. 2 e) 6-segmented, 2 basal segments large, 4 distal segments small and decreasing in size distally. First segment with 3 medial lobes bearing 2 setae, 3 setae and 2 setae and a spine respectively. There are short fine hairs medially and tiny hooked spinules on the third lobe. Second segment expanded medially with 3 setae and a fringe of short fine hairs on the medial margin. Third segment bearing 2 + 3 setae, fourth segment 2 setae, fifth segment 2 setae, sixth segment 2 setae medially and 6 on an outer lobe. Among the setae on segments 3, 4 and 5 are four with a peculiar branched structure. These

branched setae (fig. 2 b) were noticed by Mrázek (1894) on what he called the 'hinteren Maxillipeden'. He said: 'Bei unserer Form sind es gewöhnliche Borsten die aber von der Mitte ihrer Länge an gespalten sind.' It is clear that Mrázek must have examined this species very carefully although he never described it fully. These branched setae have a thickened basal portion and divide near their middle, one branch continuing as a thinner seta forming the extension of the proximal part while the other is short, broad and spatulate, fringed with short curved spinules. (. . . löffelförmig erweitert ist und einige feine steife Härchen trägt.—Mrázek, 1894.)

Similar branched setae were noted in *Pseudodiaptomus stuhlmanni* by Poppe and Mrázek (1895). They were described as being on the second maxilla, but Seymour Sewell (1932, 243) has shown that it is clear from their figure that the appendage on which these modified setae were present is that which is now termed the maxilliped. Branched setae have also been described on the maxilliped of *P. dauglishi* (Seymour Sewell, 1932) and *P. euryhalinus* (Johnson, 1939) and they are here recorded in *P. charteri* and *P. nudus*.

Swimming legs 1-4 biramous, with 2-segmented basipodite and 3-segmented exopodite and endopodite. They are similar in both sexes.

The first pair (fig. 1 k) are somewhat different to the following three pairs. The outer marginal spines of the exopod are not serrate and blade-like. The first segment of the exopod has one outer edge spine, the second no spine, and the terminal segment has two short lateral spines and a long, slender terminal spine. On the endopodite the numbers of setae on the successive segments are 1 on the first, 1 on the second and 5 on the third. On the exopodite the setation is 1 on the first, 1 on the second and 4 on the third segment.

The remaining swimming legs (2-4) (fig. 1 j) bear serrated blade-like spines on the outer distal corners of each exopod segment, an extra spine on the distal part of the outer margin of the terminal segment and a long blade-like terminal spine serrate only on its outer margin. On the exopodite the setation of the segments is: 1 on the first, 1 on the second and 5 on the third. Endopodite: 1 on the first, 2 on the second and 8 on the third. All the setae on the swimming legs are jointed and slightly thicker proximal to the joint. The first basal segment of all the legs has 2 groups of short stiff hairs on the outer margin and a long seta on the inner distal margin. The second basal segment is completely naked in the first leg and bears only a medial fringe of fine hairs in the remainder. Fine short hairs occur on the outer margins of exopod segments 2 and 3.

The ornamentation of the swimming legs may be represented by the table on the next page.

The fifth pair of legs in the female (fig. 1 d, e) is uniramous, 4-segmented and asymmetrical, particularly as regards the hyaline projections of the inner margin of the second basal segment. There seems to be some individual variation in the forms of these projections. Marsh (1933) suggests that these might be regarded as rudimentary indications of an endopod. Such rudiments are present also in *P. stuhlmanni* and *P. charteri*, but otherwise endopods of the female

LEG	PROTOPOD				ENDOPOD				EXOPOD										
	I		2		I		2		3			I		2		3			
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se	
P ₁	I	O	O	O	I	O	I	O	2	2	I	I	I	I	I	O	4	I	II
P ₂	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	I	5	I	II
P ₃	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	I	5	I	II
P ₄	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	I	5	I	II

Si, Se, St represent internal, external and terminal spines or setae respectively. The number of setae is shown in arabic numerals and spines in roman numerals.

fifth legs are completely lacking in the Pseudodiaptomidae. The outer distal angles of the first and second basal segments are produced into very small spines. The first segment of the ramus bears a spine near the distal end of the outer margin. The second segment bears a spine on the outer distal angle and is produced distally on the medial side into a large curved spiniform process bearing short bristles on the anterior and posterior margins and reaching about the midpoint of the terminal spine. The terminal spine has a small distinct basal portion bearing a slender plumose seta on its posterior face, while the long terminal blade-like portion is furnished with minute bristles on its anterior and posterior margins. Terminal spine, including the basal portion, slightly longer than the third segment. Marsh (1933, 28) points out that the distinct basal portion of the terminal spine found in some species is not a real segment but a modification of the terminal spine or 'hook'.

The egg sac is single, containing about 25 eggs arranged in a single layer curved to fit the urosome.

MALE: Length 1·35–1·45 mm. (1·05 mm., Mrázek). Habitus as in the female (fig. 3 *a*, *b*). Posterior angles of the metasome without spines. Urosome 5-segmented, uniformly slender, first and last segments shorter than the remainder. Posterior margins of the second, third and fourth segments fringed partially (2nd segment) or completely (3rd and 4th segments) with rows of coarse teeth. The caudal setae (fig. 3 *e*) are distinctly different from those of the female, for the middle seta is not expanded and all the setae are jointed about one-third of their length from the proximal end.

Left antenna 1 as in female, including setation and arrangement of aesthetascs. Right antenna 1 geniculate (fig. 3 *c*), with 21 segments, reaching the second urosome segment when extended. The last four long segments are apparently each formed by the fusion of two segments. Proportional lengths and setation as shown in figure 3 *c*. There is a hooked spine on segment 10. There is one aesthetasc on segments 2, 5, 7, 9–16, and the second last and last segments.

Male fifth legs (fig. 3 *d*) biramous and 4-segmented. In the right leg the first basal segment is naked except for some rugosity on the medial surface,

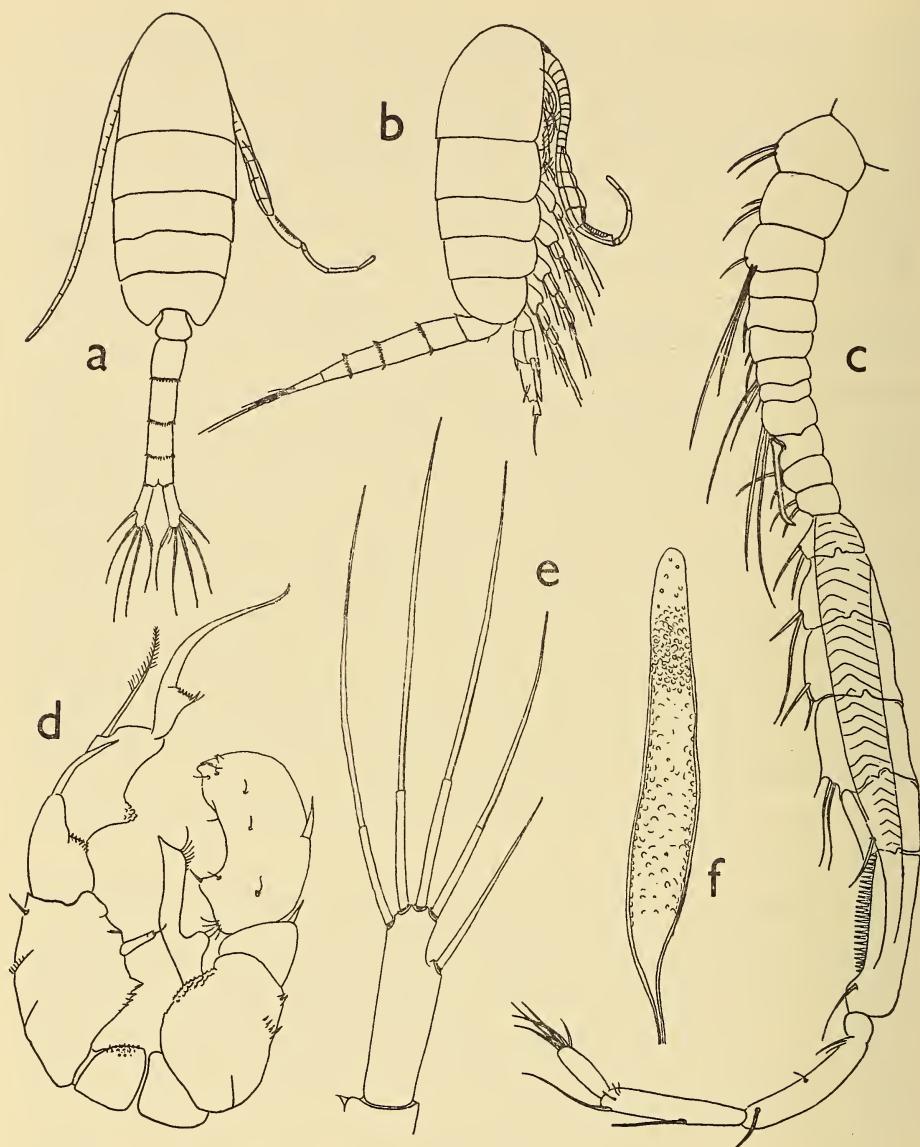


FIG. 3. *Pseudodiaptomus hessei* (Mrázek). *a*, ♂ dorsal; *b*, ♂ lateral; *c*, right antenna 1 ♂; *d*, fifth legs ♂; *e*, caudal ramus ♂; *f*, spermatophore.

The second basal segment is larger with some small spinose processes on the inner margin, and bears a small rod-like endopodite with a short terminal seta. On the outer margin there are a row of minute spinules and a fine seta near the distal angle. The exopodite is 2-segmented, the first segment produced into a curved spine at its outer distal angle, which just reaches the base of the spine on the following segment, and bears some spinules near the inner distal angle. The second segment bears a long, partly plumose spine on the distal part of the outer margin and a rugose swelling on the proximal part of the inner margin. The terminal hook has a triangular basal portion, broadest distally where it bears a row of small spinules and is produced at the outer corner into a slightly curved hook as long as the two exopod segments. The tip is recurved and minutely serrate. In the left leg the first basal segment is naked and the second basal segment bears a few spinules near the outer margin, some rugosity on the inner margin and a long hyaline endopodite. This has an expansion basally, is apically acute, and bears a fringe of about 8 fine hairs near the apex. The exopodite is 2-segmented, the first segment short, bearing a short spine at its outer distal angle. The second segment is expanded and flattened, somewhat convex posteriorly and emarginate medially. The outer distal margin is strongly convex and the inner distal margin nearly straight. There is a spine near the middle of the outer margin, and a number of small setae and spinules on the posterior surface and margins and around the apex. The left leg reaches the base of the terminal hook of the right leg.

The spermatophore (fig. 3 f) is fusiform, stalked, and $250\text{--}400\mu$ long.

COLOUR: Unpigmented except for some orange coloration around the mouth-parts.

Types

Hypotypes, S.A.M. A10958, in the South African Museum.

Remarks

This species was named after P. Hesse who first collected it. It was originally described as a *Schmackeria* but was correctly transferred to the genus *Pseudodiaptomus* by Giesbrecht and Schmeil (1898). The species is easily distinguished by the broad middle caudal seta in the female and by the characteristic fifth legs in the male. Our specimens are considerably larger than those originally described.

Pseudodiaptomus charteri sp. n.

(Figs. 4 a-j)

Occurrence

Abundant in the estuaries of St. Lucia and Richards Bay on the Natal coast. Specimens have been found in water with salinity ranging from about $10^{\circ}/_{\text{oo}}$ to about $38^{\circ}/_{\text{oo}}$.

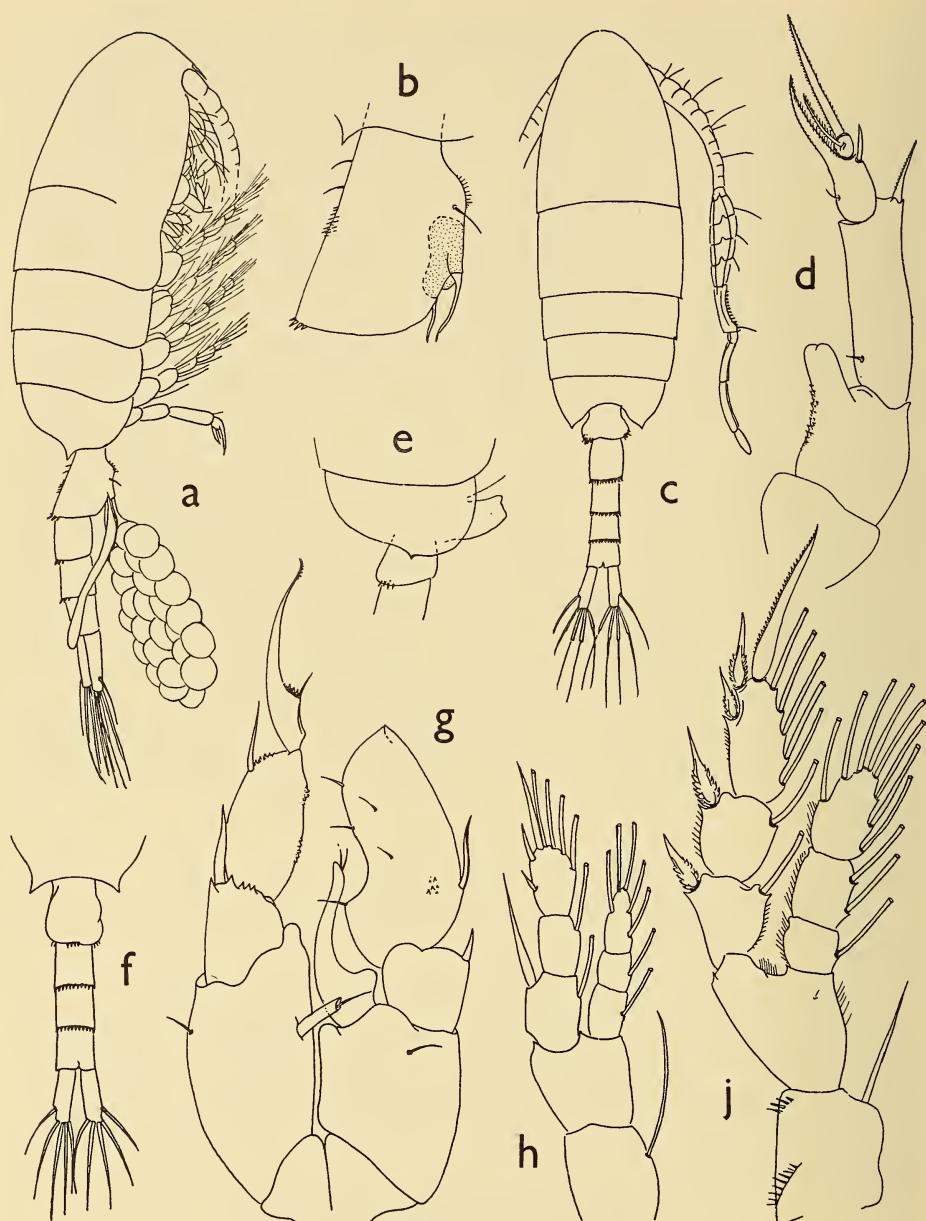


FIG. 4. *Pseudodiaptomus charteri* sp. n. a, ♀ lateral; b, ♀ genital segment lateral; c, ♂ dorsal; d, fifth leg ♀; e, posterior angle of ♂ metasome lateral; f, ♀ urosome dorsal; g, ♂ fifth legs; h, first swimming leg; i, fourth swimming leg.

Description

FEMALE: Length 1·40–1·55 mm. Prosome slender, viewed dorsally more than two and a half times as long as wide. Head rounded anteriorly. Fourth and fifth pedigerous segments fused. Posterior angles of metasome bearing a sharp spine on each side near the middle of the posterior margin. Rostrum well developed with two strong filaments which reach the middle of the proximal segment of the first antenna.

Urosome (fig. 1 f) 4-segmented and less than two-thirds as long as the prosome. Genital segment (fig. 4 b) asymmetrical with irregular lateral swellings in the posterior part and a prominent genital boss ventrally. A few coarse teeth are present on the postero-dorsal margin, some setae dorsally and laterally and a patch of fine hairs on the mid-dorsal surface. The genital boss is similar to that of *P. hessei* with genital flaps, setae and an anterior fringe of spinules. The second and third urosome segments are furnished with rows of coarse teeth on their postero-dorsal margins. The caudal rami are divergent, more than 3 times as long as wide and furnished with fine hairs on their inner margins. The caudal setae are all similar, unjointed but tapering sharply to the thinner distal part.

Antenna 1 of 21 segments, reaching the second urosome segment when extended. Proportional lengths, setation and arrangement of aesthetascs as in *P. hessei*.

Antenna 2, mandible, maxilla 1 and 2 and maxillipeds all apparently identical with those of *P. hessei*. The same peculiar branched setae are present on the maxillipeds.

Swimming legs 1–4 as in *P. hessei* except in the following respects. In the first leg (fig. 4 h) the terminal exopod spine is shorter and there are apparently no spinules on the first basal segment. In legs 2–4 (fig. 1 j) the second basal segment is longer and narrow proximally and there are fine short hairs on the outer margin of the exopod and between it and the endopod on the second basal segment. The setal formula is identical with that of *P. hessei*.

The fifth pair of legs in the female (fig. 4 d) is similar to those of *P. hessei*. The inner processes of the second basal segment are furnished with minute spinules medially. The first outer spine is minutely serrate. A single hair is present on the medial margin of segments 3 and 4. The spiniform process of the fourth segment reaches beyond the midpoint of the terminal spine. Terminal spine, including the basal portion, slightly shorter than the third segment.

Egg sac as in *P. hessei*.

MALE: Length 1·25–1·30 mm. Habitus similar to the female (fig. 4 c). Posterior angles of the metasome bearing very small spines on the posterior margin (fig. 4 e). Urosome 5-segmented, as in *P. hessei* except for some postero-lateral spinules on the first segment and a mid-ventral patch of hairs on the second segment. Caudal setae jointed about one-third of their length from the proximal end as in the male of *P. hessei*. Left antenna 1 as in female. Right antenna

1 geniculate with 21 segments, reaching the second urosome segment when extended. Proportions and setation as in *P. hessei*.

The male fifth legs (fig. 4 g) are similar to those of *P. hessei* in general form but show the following differences. In the right leg the first basal segment is naked and smooth, second basal segment without inner spinose processes or outer row of spinules. Outer spine of first exopod segment straight and not reaching the base of the second outer spine. The latter non-plumose and not reaching beyond the thickened basal portion of the terminal hook. There are some rugose patches on the medial and distal margins of the second segment but no inner swelling. Terminal hook not as long as the two exopod segments. In the left leg the second basal segment is without medial or outer spinules. The endopodite is apically rounded and bears only 2 fine hairs near the apex. The second exopodite segment is a different shape to that of *P. hessei*, with the outer distal margin only slightly convex and the inner distal margin strongly convex. The outer marginal spine is longer and more proximal.

The spermatophore is similar to that of *P. hessei*, 400–600 μ long. Frequently more than one are attached to a female.

COLOUR: Unpigmented except for some orange coloration in the anterior part of the metasome.

Types

Types are in the South African Museum, Cape Town. Holotype, male, S.A.M. A10959; allotype, female, S.A.M. A10960; paratypes, S.A.M. A10961; from St. Lucia Lagoon, Natal, plankton sample STL-G2, collected by R. S. Crass on 21/9/54.

Remarks

This species is named after Mr. R. R. Charter in recognition of his extensive unpublished work on the Copepoda of South Africa. *P. charteri* differs from *P. hessei* in a large number of characters which are mentioned in the above description. It may be distinguished most easily in the female by the caudal setae which are all similar and in the male by the fifth legs, particularly the shorter marginal spines on the right leg.

Pseudodiaptomus nudus Tanaka (Figs. 5 a–j)

Pseudodiaptomus serricaudatus (non T. Scott 1894). Cleve 1904, 196.
Pseudodiaptomus nudus Tanaka 1960, 47, pl. 21, figs. 1–9.

Occurrence

Present in neritic waters off the Cape and abundant over the Agulhas bank. Found mostly in sea water with salinity near 35‰ but does penetrate into water of reduced salinity.

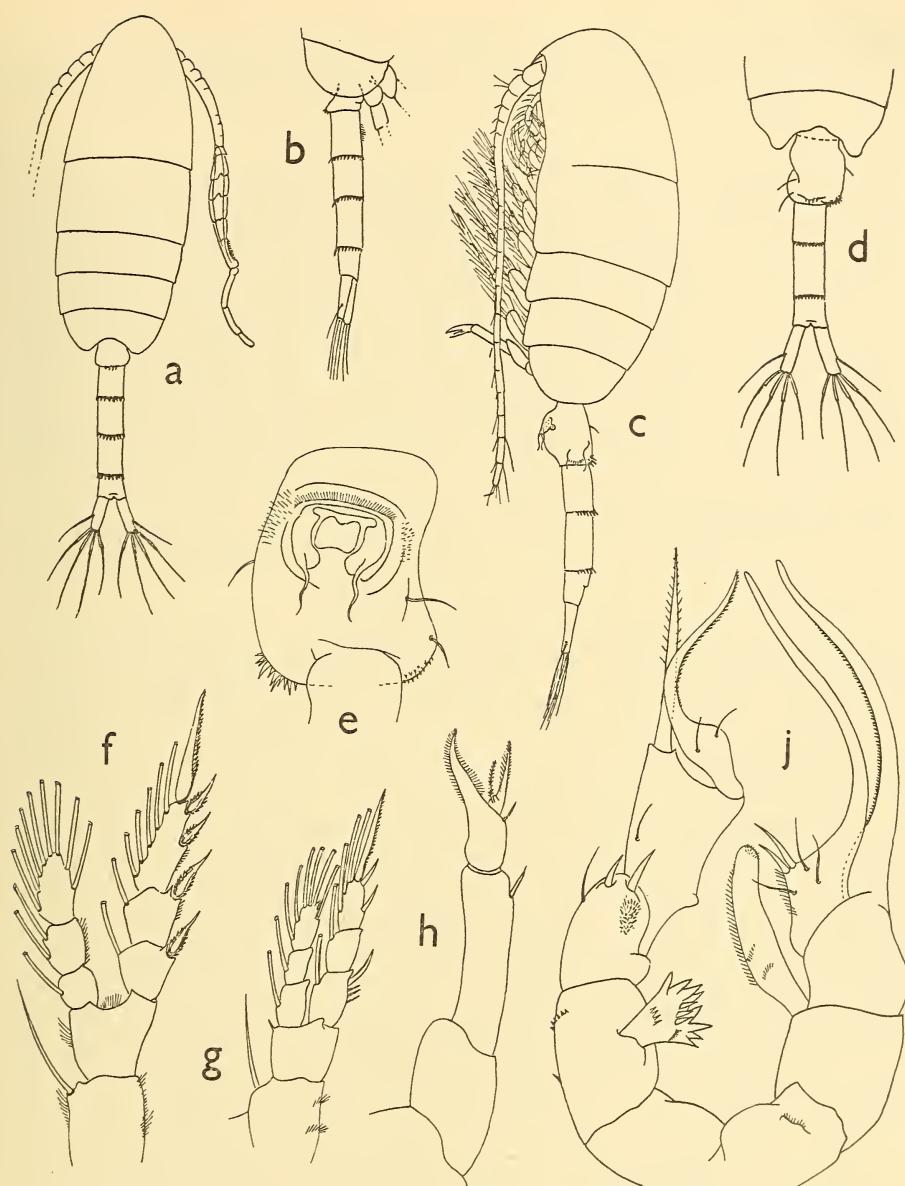


FIG. 5. *Pseudodiaptomus nudus* Tanaka. *a*, ♂ dorsal; *b*, ♂ urosome lateral; *c*, ♀ lateral; *d*, ♀ urosome dorsal; *e*, ♀ genital segment ventral; *f*, fourth swimming leg; *g*, first swimming leg; *h*, fifth leg ♀; *i*, fifth legs ♂.

Known distribution

Station 8 of the Japanese Antarctic Research Expedition off Cape Agulhas (Tanaka, 1960).

Description

FEMALE: Length 1·30–1·40 mm. Prosome slender, viewed dorsally approximately two and a half times as long as wide (fig. 5 c). Head rounded anteriorly. Posterior angles of the metasome rounded and naked. Rostrum well developed with 2 strong filaments which reach the proximal segment of the first antenna.

Urosome (fig. 5 d) 4-segmented, slightly over half as long as metasome. Genital segment (fig. 5 e) asymmetrical, the right side inflated and the left side depressed, and a prominent genital boss ventrally. The right distal angle is furnished with a group of small spines. The left lateral swelling bears 2 setae distally and some minute spinules. The genital boss is similar to that of *P. hessei* but also bears spinules on the periphery. There are rows of coarse teeth on the postero-dorsal margins of the second and third urosome segments and a few on the genital segment. Proportional lengths of urosome segments are given by Tanaka (1960). The caudal rami are divergent, approximately 3 times as long as wide, and the setae are jointed and not expanded.

Antenna 1 of 21 segments, reaching the posterior margin of the second urosome segment when extended. Proportional lengths of segments are given by Tanaka (1960). Setation and arrangement of aesthetascs as in *P. hessei*.

Antenna 2, mandible, maxilla 1 and 2 and maxillipeds all apparently identical with those of *P. hessei*. The same peculiar branched setae are present on the maxillipeds.

Swimming legs 1–4 resemble those of *P. hessei* except in the following respects. In the first leg (fig. 5 g) the terminal exopod spine is serrate and about as long as the last 2 exopod segments. On the first exopod segment there are 3 small spinules proximal to the outer marginal spine which is shorter than in *P. hessei*. The second basipod segment bears a small inner distal spinule. The distal endopod segment bears 6 setae. In swimming legs 2–4 (fig. 5 f) the distribution of fine short hairs is similar to that in *P. charteri* but even more extensive.

The ornamentation of the swimming legs may be represented as follows:

LEG	PROTOPOD				ENDOPOD				EXOPOD									
	1		2		1		2		3		1		2		3			
	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se		
P ₁	I	O	I	O	I	O	I	O	3	2	I	I	IV	I	O	3	I	II
P ₂	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	5	I	II
P ₃	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	5	I	II
P ₄	I	O	O	O	I	O	2	O	4	2	2	I	I	I	I	5	I	II

The female fifth legs (fig. 5 h) are uniramous and 4-segmented, lack medial processes on the second basal segment, and are nearly but not quite

symmetrical. The terminal spine is shorter than the spiniform process of the fourth segment, and bears a slender plumose seta in place of the short, stout, serrate spine of *P. serricaudatus*.

The egg sac is single and similar to that of *P. hessei*.

MALE: Length 1·15–1·20 mm. Habitus similar to the female (fig. 5 a). Urosome (fig. 5 b) 5-segmented and similar to that of *P. hessei*. Proportional lengths of the segments are given by Tanaka (1960). The second urosome segment bears a mid-ventral patch of hairs. Caudal setae as in the female. Antenna 1, 21-segmented, right geniculate, as in *P. hessei*. Proportional lengths of the segments are given by Tanaka (1960). The male fifth legs (fig. 5 j) are in the main identical with those of *P. serricaudatus* (T. Scott) (1896), but in the right leg the second marginal spine reaches as far as the terminal hook does. The endopod is more complex than in *serricaudatus*. There are also minor differences in setation and proportions. The spermatophore is similar to that of *P. hessei*.

COLOUR: Scattered orange pigment is present throughout the metasome and the female genital segment. The urosome is colourless apart from a distinctive red patch in the anal segment.

Types

3 ♀♀, 8 ♂♂ and 1 juv. deposited in the National Science Museum of Japan. There are many hypotypes and topotypes in the South African Museum (S.A.M. A10962).

Remarks

Pseudodiaptomus nudus Tanaka differs from *P. serricaudatus* (T. Scott) (1896), to which it is closely allied, in the following characters. In both sexes the posterior thoracic margin is spineless, from which (presumably) the name *nudus* is derived. This species is somewhat larger. In the female the genital segment is asymmetrical and the terminal spine and seta of the fifth legs are different. In the male fifth legs the right endopod is more complex and the terminal spine of the right leg is longer. *P. nudus* is easily distinguished from the other South African species by the naked posterior angles of the metasome in the female and the characteristic fifth legs of the male. The above account of this species includes some small additions and corrections to Tanaka's (1960) description. I am somewhat doubtful as to whether this species is really distinct from *serricaudatus* but a re-examination of T. Scott's types will be necessary to determine this, for his original description is inadequate. I have examined Cleve's (1904) specimens of *serricaudatus* in the South African Museum (S.A.M. A2067, A2068) from off Cape Infanta, and they are of the *nudus* form.

Both *nudus* and *serricaudatus* should be maintained in the genus *Pseudodiaptomus* rather than being placed in the genus *Schmackeria* as suggested by Marsh (1933). They do not possess the characteristic long, curved projection on the inner border of the second segment of the left fifth leg of the male, but have a normal endopod similar to that of the African and American species.

DISCUSSION

It is perhaps appropriate now to discuss the relationships of this group of species, for the description of these three species clarifies the picture of the distribution of this group round the coast of Africa. It is now clear that the African species have a number of important features in common and tend to constitute a distinct morphological and zoogeographical unit. Early authors tended to overlook this. Mrázek (1894), for example, in his note on *P. hessei* compares it to *gracilis* Dahl (1890) from South America and *forbesi* Poppe & Richard (1890) from China. It is now apparent that both of these are really extremely divergent forms and the only resemblances are those common to the genus or family. Brehm (1951), when discussing the relationships of *P. pauliani* from Madagascar, persists in comparing African and American species, on the basis of such characters as the possession of a left endopod. He also says that all attempts to arrange the Pseudodiaptomidae into groups that are morphologically and also geographically common are in vain, but it would seem that this is now possible. All the species found round the coast of Africa are characterized by the possession of both left and right endopods in the fifth legs of the male. Certain oriental species also possess both endopods but they may be separated on the basis of other features such as the possession of a 'Y'-shaped right endopod in the fifth leg of the male.

A series of species related to *P. hessei* and *P. charteri* are found on the east coast of Africa. *P. stuhlmanni* (Poppe & Mrázek) (1895) was described from the estuary of the Quilimane river on the coast of Mozambique north of Beira. The male fifth legs of this species are almost identical with those of *P. charteri* except for the strikingly different right endopod which is spatulate, furnished with bristles terminally and with a large stout claw at its base. *P. salinus* (Giesbrecht) (1896) is a marine species known from the north-west Indian Ocean and Red Sea (Sewell, 1947). The male fifth legs of this species although still basically similar in structure to the South African species show further differences in details and proportions. The two species described from Madagascar, *P. pauliani* Brehm (1951) and *P. batillipes* Brehm (1954), are also related but reveal some distinctive modifications such as the inner projection on the second basal segment of the left male fifth leg. *P. ardjuna* Brehm (1953) from Salsette Island near Bombay on the west coast of India falls into the African group also, on the basis of the structure of the male fifth legs as described by Brehm (1953).

Ummerkutty (1961), however, has shown that specimens of this species from off Mandapam in the Gulf of Mannar region of south-east India have a 'Y'-shaped spinous right endopod in the fifth leg of the male such as is found in the oriental '*hickmani* group'. It would be interesting to re-examine material of this species from Bombay to see whether this difference really exists.

On the west coast of Africa *P. hessei* has been recorded from the mouth of the Congo, while a related species is figured by Marques (1951) from Portuguese Guinea.

The status of the remaining South African species, *P. nudus* Tanaka 1960, is somewhat doubtful. It is obviously very closely allied to *P. serricaudatus* (T. Scott) (1894) described from the Gulf of Guinea, but differs slightly from the original description and figures. Marques (1947), however, gives figures of specimens of *P. serricaudatus* from Portuguese Guinea that resemble the *nudus* form. *P. serricaudatus* has also been recorded from Sierra Leone (Bainbridge, 1959) and Angola (Marques, 1958) and various other localities on the West African coast. In the Indian Ocean *P. serricaudatus* has been recorded from the east and west coasts of India, Ceylon, the Arabian Sea, south Arabian coast, Gulf of Aden and Red Sea (Sewell, 1947). Sewell suggested that it appeared to be an Indian Ocean form that had managed to get round the Cape of Good Hope into the Gulf of Guinea, where it was originally taken. If the *nudus* form from the Cape is really distinct it is likely that the Indian Ocean form will also prove to be different from the originally described West African form, which is completely geographically isolated.

The left exopod of the fifth leg of *P. serricaudatus* and *P. nudus* with two long curved spines is quite different from that of any other pseudodiaptomid, but the presence and nature of the left and right endopods indicates that their affinities are with the other African species.

P. nudus, like *P. serricaudatus*, appears to be essentially a neritic marine species not found far from land except over the wide, shallow Agulhas bank. It penetrates into the mouths of estuaries, however, and can live in water of reduced salinity. *P. hessei* and *P. charteri*, like *P. stuhlmanni*, are essentially estuarine species found in water of reduced salinity and in hypersaline lagoons, and occur only rarely together with *P. nudus*. There is thus an ecological separation between these species despite the geographical overlap.

Specimens of all three species occurring in South Africa are considerably larger than the same or related species from elsewhere on the African coast.

The question of the grouping of the species of *Pseudodiaptomus*, *sensu-lato* and the relationships and zoogeographical significance of these groups is being considered further in a forthcoming paper.

KEY TO THE SOUTHERN AFRICAN SPECIES OF PSEUDODIAPTOMUS

Key to the females (urosome 4-segmented)

1. Posterior corners of metasome without spines	..	..	..	..	..	<i>nudus</i>
2. Posterior corners of metasome bearing spines	..	..	..	..	..	3
3. Middle caudal seta broad and blade-like	..	..	..	..	..	<i>hessei</i>
4. Middle caudal seta identical to other setae	..	..	..	..	..	<i>charteri</i>

Key to the males (urosome 5-segmented)

In the right fifth leg:

1. Second marginal spine reaching as far as tip of terminal hook	..	..	<i>nudus</i>
2. Second marginal spine much shorter than terminal hook	..	..	3
3. Second marginal spine not reaching beyond thickened basal part of terminal hook	..	..	<i>charteri</i>
4. Second marginal spine reaching well beyond thickened basal part of terminal hook	..	..	<i>hessei</i>

SUMMARY

Descriptions and figures of the three species of Pseudodiaptomidae occurring in southern African waters are given. A full description is given of *P. hessei* (Mrázek, 1894), which was never fully described. A new species, *P. charteri*, is described. A further description of *P. nudus* (Tanaka, 1960) is given. The affinities of these species with other members of this interesting genus are discussed. The existence of a distinct African group of pseudodiaptomids characterized primarily by the possession of both left and right endopods in the fifth legs of the male is noted. It is considered that *nudus* and *serricaudatus* should be maintained in the genus *Pseudodiaptomus* and not placed in the genus *Schmackeria* as had been suggested. It is further noted that the affinities of the latter two species lie with the African group of species.

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REFERENCES

- BAINBRIDGE, V. 1959. *The Plankton of inshore waters off Sierra Leone*. London: H.M. Stationery Office.
- BREHM, V. 1951. *Pseudodiaptomus pauliani* (Crustacea, Copepoda). Der erste Vertreter der Pseudodiaptomiden in der madagassischen Fauna. *Mem. Inst. Sci. Madagascar* (A), **6**, 419–425.
- BREHM, V. 1953. Indische Diaptomiden, Pseudodiaptomiden und Cladoceren. *Öst. zool. Z.* **6**, 241–345.
- BREHM, V. 1954. *Pseudodiaptomus batillipes spec. nov.*, ein zweiter Pseudodiaptomus aus Madagaskar. *S.B. öst. Akad. Wiss. Math.-nat. Kl., Abt. I*, **163**, 603–607.
- CLEVE, P. T. 1904. The Plankton of the South African Seas. I. Copepoda. *Mar. Invest. in. S Afr.* **3**, 177–210.
- DAHL, F. 1894. Die Copepodenfauna des unteren Amazonas. *Ber. Naturf. Ges. Freiburg i.B.* **8**, 10–23.
- GIESBRECHT, W. 1896. Über pelagische Copepoden des Rothen Meeres, gesammelt vom Marinestabsarzt Dr. Augustin Krämer. *Zool. Jahrb. (Abt. Syst.)* **9**, 315–328.
- GIESBRECHT, W., & SCHMEIL, O. 1898. Copepoda. I, Gymnoplea. *Tierreich. Lief 6*, 1–169.
- GOODING, R. U. 1957. On some copepoda from Plymouth mainly associated with invertebrates, including three new species. *J. mar. biol. Ass. U.K.* **36**, 195–221.
- HERRICK, C. L. 1884. A final report on the crustacea of Minnesota included in the orders Cladocera and Copepoda. *Rep. Minn. geol. nat. Hist. Surv.* **12**, 1–191.
- JOHNSON, M. W. 1939. *Pseudodiaptomus (Pseudodiaptallous) euryhalinus*. A new sub-genus and species of copepoda with preliminary notes on its ecology. *Trans. Amer. microsc. Soc.* **58**, 349–355.
- MARQUES, E. 1947. Copépodes da Guiné Portuguesa. *Ann. Junta. Invest. Ultramar., Lisboa* **2**, Tom. 3, 31–46.

- MARQUES, E. 1951. Copépodes encontrados no conteúdo gástrico de alguns clupeídeos da Guiné Portuguesa. *Ann. Junta. Invest. Ultramar., Lisboa* 6, Tom. 4, Fasc. 1, 11–18.
- MARQUES, E. 1958. Copépodes marinhos de Angola. 2^a campanha (1952–1953). *Mem. Junta. Invest. Ultramar., Lisboa* (2) 4, 199–222.
- MARSH, C. D. 1933. Synopsis of the calanoid crustaceans, exclusive of the Diaptomidae, found in fresh and brackish waters, chiefly of North America. *Proc. U.S. Nat. Mus.* 82, 1–58.
- MRÁZEK, A. 1894. Über eine neue Schmackeria (*Schm. hessei* n. sp.) aus der Kongo-Mündung. *S.B. böhm. Ges. Wiss. Math-nat. Kl.* 1894, art. 24, 1–3.
- MRÁZEK, A. 1901. Süßwasser-Copepoden. *Ergeb. Hamburg Magalhaens. Sammelr.*, Lief 6, no. 2, 29 pp. 4 pl.
- POPPE, S. A., & MRÁZEK, A. 1895. Die von Herrn Dr. F. Stuhlman auf Zanzibar und dem gegenüberliegenden Festlande gesammelten Süßwasser—Copepoden. *Mitt. nat. Mus. Hamburg* 12 (1894), 123–134.
- POPPE, S. A., & RICHARD, J. 1890. Description du *Schmackeria forbesi* n.g. et sp. calanide nouveau recueilli par M. Schumacker dans les eaux douces des environs de Shanghai. *Mem. Soc. zool. France* 3, 396–400.
- SEWELL, R. B. SEYMOUR. 1932. The Copepoda of Indian Seas. Calanoida. *Mem. Ind. Mus. Calcutta* 10, 223–407.
- SEWELL, R. B. SEYMOUR. 1947. The free swimming planktonic Copepoda. Systematic account. *Sci. Rep. Murray Exped.* 8 (1), 1–303.
- SCOTT, T. 1894. Report on the Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc. *Trans. Linn. Soc. Zool.* 6, 1–162.
- TANAKA, O. 1960. Pelagic Copepoda. *Biol. Results Jap. Antarct. Res. Exped.* 10, 1–191.
- UMMERKUTTY, A. N. P. 1961. Studies on Indian copepods 4. Description of the female and a redescription of the male of *Pseudodiaptomus ardjuna* Brehm (Copepoda, Calanoida) with notes on the distribution and affinities of the species. *J. mar. biol. Ass. India* 2, 179–185.